Appendix 2. The NOAA Component of ITCT

NOAA will undertake to augment ITCT activities by developing capabilities to better quantify the transport of pollution into and from North America. Emissions from North America can impact European air quality. In addition, pollutants transported into the U.S. become part of the "background" that defines a limit for air quality management. The research will initially focus on the long-lived pollutants, CO, ozone and fine particles. The research will attempt to define the location of the sources of the pollutants and determine the nature of those sources. These sources will include natural sources, such as forest fires, volcanoes, and wind-blown dust; manmade sources, such as transportation and heavy industry; and in-route sources, including ships and aircraft. The proposed research will investigate transport across the Pacific and Atlantic Oceans and North Polar Region. In addition, the chemical transformation and deposition that may occur in the oceanic and polar regions will be studied. The program will:

- conduct airborne exploratory studies of airflow from the Pacific into the western U.S. in early 2001,
- develop surface monitoring capabilities and deploy an intensive field study in 2002 to investigate and quantify trans-Pacific transport, and
- analyze existing data and conduct further measurements to determine the influence of biomass burning at high latitudes.

A. Exploratory Field Study in 2001

During January and February 2001, the Winter Storm Reconnaissance, 2001 program will operate the NOAA Gulfstream IV SP aircraft from Hawaii. Simultaneously, the PACJET (Pacific Landfalling Jets Experiment) program will operate the NOAA WP-3 Orion from California. The primary goal of both of these field programs is to improve meteorological forecasts for storms that strike the U.S. Pacific Coast. The areas of operation of the two aircraft (mid to eastern Pacific) are within the primary transport pathways of pollution between Asia and North America. In addition, the mid-Pacific is a region of intense stratosphere-troposphere

exchange associated with breaking Rossby waves. These programs offer us the opportunity to carry out an exploratory study of the pollutant concentrations and transport in this region.

On a noninterference basis, we will measure ozone from the Gulfstream IV and ozone and carbon monoxide (CO) from the WP-3. The mid-Pacific ozone data from the Gulfstream IV will provide the basis for gauging the influence of stratosphere-troposphere exchange on the tropospheric ozone budget of the Pacific region and, when combined with trajectory analysis, will give an indication of transport of anthropogenic pollution during the winter season. The eastern Pacific ozone and CO data from the WP-3 will indicate the influence of the transport of Asian pollution to the western U.S. coast. It will also gauge the effect of the recirculation of North American emissions, and will track the inflow of natural ozone from the stratosphere-troposphere exchange in the mid-Pacific. The results of this exploratory study will provide important guidance for planning the much more extensive field mission planned for the following winter-spring period.

B. Development of surface monitoring capabilities

In order to better track the long-range transport of pollution to and from North America and to monitor the change in the pollutant distributions with time, additional surface monitoring sites and upgrades to existing sites are planned.

Azores. Two measurement sites are planned for the Azores in the central North Atlantic Ocean. These projects are outgrowths of the CO, ozone, and nitrogen oxides measurements made at Terceira Island in 1993 [*Peterson et al.*, 1998; *Parrish et al.*, 1998]. The Pico Exploratory Atmospheric Chemistry Observatory (PEACO) is a planned two-year study of atmospheric chemistry in the lower free troposphere (FT) over the Azores. The measurements will be made at the summit of Pico mountain on Pico Island at an altitude of 2200 m, a height that is frequently in the FT according to ozone soundings made at the adjacent island of Terceira [*Oltmans et al.*, 1996]. Despite the significant logistical and organizational difficulties involved in operating on a mountaintop with no existing access or electrical power, measurements are

scheduled to begin in early summer 2001. Government permission has been received to set up the site and make measurements for a 2-year period.

The primary objectives of the measurements are to quantify the impact of continental outflow on the budget of ozone over the North Atlantic and to assess the relative importance of ozone and ozone precursor export. However, it is expected that the measurements will be used for a variety of other purposes, including aerosol studies. Initially, the measurements will include CO, ozone, and standard meteorological observations. Future measurement additions include black carbon, nonmethane hydrocarbons, and nitrogen oxides. Space and electrical power are quite limited and instruments must be remotely monitored and controlled.

The Portuguese Meteorological Institute is planning a long-term Global Atmospheric Watch (GAW) site in the marine boundary layer (MBL) in the Azores. The value of an Azores GAW site was mentioned in a recent WMO informal report ("Final Report of the Consultation of Experts on Carbon Monoxide Instrumentation for Remote GAW Sites, Geneva, 8-10 September 1999"). Measurements at this site, in conjunction with the mountaintop measurements, will allow the investigation of FT/MBL exchange and the budgets of ozone and its precursors in the MBL of the central North Atlantic.

NOAA Baseline Observatories. The NOAA Climate Monitoring and Diagnostics Laboratory (CMDL) operates long-term atmospheric observatories at Pt. Barrow, Alaska and Mauna Loa, Hawaii. Presently, the measurements are aimed at climate forcing and ozone-depleting agents such as CO_2, CH_4, O_3, N_2O, CFC's, aerosols and solar incoming and upwelling radiation. In addition, persistent organic pollutants and mercury have been added recently at Barrow. Measurements at the observatories will be enhanced as part of the ITCT Program. During Spring 2001, a pilot intensive will be held at Mauna Loa (Springtime TRansport of Effluents from Asia to Mauna Loa – STREAM) during which additional measurements such as continuous CO, persistent organic pollutants, mercury, nitrogen oxides, aerosol chemistry, and hydrocarbons (Proton Transfer Mass Spectrometry and GC-MS instruments) will be conducted. The results of this pilot campaign will be used to evaluate possible observatory participation during the proposed 2002 intensive field study.

Northwestern U. S. Pacific Coast. An initial study of the factors that influence the airquality on the western fringes of the United States will be undertaken during the spring of 2002 at sites that will be identified and developed during the coming year (2001). Possible sites include Trinidad Head, CA, where CMDL presently operates both a Dobson ozone spectrophotometer and an ozonesonde station. In addition, the NASA Advanced Global Atmospheric Gases (AGAGE) program measures various chlorofluorocarbons (CFCs) at this site. Both programs operate through cooperation with Humboldt State University. CMDL plans to expand its background measurements of air-quality parameters at this site in the future and to work with other agencies and universities to develop a distributed baseline observatory on the west coast of the U.S.

C. Field Study in 2002

During Spring 2002, NOAA will conduct airborne measurements of the concentrations of ozone, fine particles, their precursors, the photochemical intermediates, and other photochemical products, as well as other atmospheric parameters. The study will be based on the U.S. West Coast, and will investigate how inflow from the Pacific basin affects the chemical processing and removal of compounds of anthropogenic origin that influence the regional budgets of ozone and fine particles downwind over the continental U.S.

The objectives for this program are to provide information that pertains to:

(1) *Marine boundary layer and free troposphere:*

- inflow to U.S. continent, upwind of coastal shipping lanes to address issues of intercontinental transport [*Parrish et al.,* 1992; *Jaffe et al.,* 1999; *Jacob et al.,* 1999];
- new particle formation, composition, growth, and evolution in low-hydrocarbon environments [*Weber et al.,* 1999];
- influence of coastal ship traffic on marine boundary layer (MBL) NO_x levels, ozone, and aerosols; mixing and oxidation in ship plumes [*Corbett and Fischbeck*, 1997; *Lawrence and Crutzen*, 1999; *Kasibhatla et al.,* 2000];

- horizontal and vertical distributions of ozone, CO, aerosol, etc. during inflow periods, to which U.S. emissions are added. This will provide a benchmark for future investigation of hemispheric impacts of increasing Asian emissions.
- provide data to constrain heterogeneous processing of HNO_3 on aerosols [*Liu et al.*, 1992; *Chatfield*, 1994; *Jacob et al.*, 1996; *Lary et al.*, 1997].

(2) *Continental boundary layer and free troposphere:*

- impact of West Coast emissions on downwind ambient concentrations, in contrast to the East Coast situation studied in previous NARE missions. Ozone production efficiency of NO_x emissions from large combustion sources when added to relative clean marine air;
- vertical transport, oxidation, and sinks of ozone, aerosols, and their precursors emitted from coastal metropolitan areas into marine air masses, through the contrast of upwind (marine) profiles with downwind (impacted continental) profiles;
- ozone and aerosol processing and growth as marine air is advected over pine forests, where pinenes and their oxidation products contribute very significantly to the biogenic volatile organic compounds (BVOC);
- vertical transport, oxidation, and export of anthropogenic NOx, hydrocarbons, PAN, and ozone into the free troposphere (FT); human influence on FT ozone from West Coast inland [*Parrish et al.,* 1993; *Chin et al.,* 1994; *Parrish et al.,* 1998];
- inflow from Central America and Mexico and the impact on U.S. aerosol loading from sources from Central America and Mexico;
- West Coast urban/point source NOx plume oxidation processes, where prevailing non-methane hydrocarbon (NMHC) concentrations are lower and not as strongly dominated by isoprene (sources in deserts, sources in pine forest) in contrast to those in the southeastern US [*Ryerson et al.*, 1998]

(3) how chemical processing on aerosols influences ozone formation;

(4) how the atmospheric oxidation leading to ozone formation also leads to aerosol formation;

(5) how atmospheric chemistry influences the growth and/or the chemical composition of aerosols; and

(6) the effects of dynamic (mixing) factors on the observed concentrations of gas phase and aerosol species.

D. Influence of biomass burning at high latitudes

For many years, the influence of biomass burning on regional air quality and climate variability has been recognized. Much of the emphasis of these studies has been to determine the influence of intentional burning related to agriculture and land use in regions between 20ºN and 20ºS. However, biomass burning at high latitude in the Northern Hemisphere has important regional and even global consequences. In the summer of 1995, elevated concentrations of CO were observed in the southeastern and eastern United States. This CO could not be explained by emissions from known anthropogenic sources in the United States. The source of this CO proved to be a large forest fire that was burning in the boreal forest of northwestern Canada (*Wotawa and Trainer*, 2000). Based on the forest area burned in Canada annually, it is estimated that on-average these fires amount to approximately 17% of the annual U.S. CO emissions.

Beyond regional impacts in the United States, during intense fire years the forest fires in the high latitudes (> 40ºN) may have an influence on the summertime CO background over the Northern Hemisphere. These fires are unintentional, often generated by lightning. They generally occur in the more remote boreal forests. These "wildfires" are modulated by regional climate variability and are most prevalent during periods of decreased precipitation. These fires emit significant quantities of trace gases CO, CO_2, CH_4, VOCs, and NO_x. It is very important that hemispheric and global trends of trace gases can be estimated considering the influence of boreal fires.

Several research projects will be undertaken to better understand the roles played by these fires.

- Long-term CO measurements data will be investigated to search for inter-annual variability consistent with seasonal variations and magnitude of high-latitude fires.
- Determine the influence of NO_X and VOC emissions for high-latitude fires on summertime ozone levels over North America.

- Determine the chemical composition of gases and fine particles emitted by these fires and the chemical evolution of those emissions once they enter the atmosphere.

Determine the influence of these aerosols on hemispheric climate forcing and variability with particular emphasis on the their impact in the North Polar Region.